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RADIOGRAPHIC EVALUATION OF ALVEOLAR BONE IN MANDIBULAR IMPLANT OVERDENTURE RETAINED BY PEEK BAR ATTACHMENT AFTER OCCLUSAL ADJUSTMENT FOLLOWING TWO DIFFERENT METHODS (COMPUTERIZED OCCLUSAL ANALYSIS AND ARTICULATING PAPER)

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ABSTRACT

Objectives: This study investigated the impact of performing occlusal adjustment after using two different methods (T scan and articulating paper) on the variations in vertical bone height surrounding dental implants retaining mandibular overdentures retained by a PEEK bar.

Materials and Methods: 16 male completely edentulous patients with an age ranging from 55 to 65 years participated in this study. Two implants were inserted in the canine areas bilaterally. Every patient received an implant supported mandibular overdenture retained by a CAD/CAM machined PEEK bar. The patients were randomly divided into two equal groups depending on the occlusal error detection technique: For **Group I** occlusal adjustment was done after using computerized occlusal analysis (T scan III device) to identify occlusal prematurities, While for **Group II** occlusal adjustment was done after using articulating paper. Radiographic evaluation of bone height around the implants was done at the time of delivery, 6 months and 12 months later through digital periapical radiographs

Results: There was a gradual increase in the vertical bone loss in both groups. However, group II showed significantly more vertical bone height loss around the implants than group I.

Conclusion: Within the limitations of this study, it is possible to conclude that using computerized occlusal analysis (T scan III device), as opposed to articulating paper, resulted in a more accurate occlusal adjustment which in turn resulted in a reduced amount of bone loss around dental implants mandibular- bar retained overdentures.

KEYWORDS: Dental implants, Overdentures, Milled bars, CAD/CAM technology, Radiographic evaluation, Bone loss.

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INTRODUCTION

Complete edentulism presents a number of difficulties that frequently have an impact on the participants health and quality of life [1]. Long-term edentulism causes the alveolar ridge to deteriorate, which makes oral rehabilitation difficult for patients wearing removable prosthesis[2]. Additionally, individuals with prolonged edentulism report having trouble eating a variety of foods and as a result, have poor dietary habits[3]. The use of dental implants in such cases enhances the stability, retention and masticatory efficiency of the removable prostheses and significantly improves patient's comfort and quality of life[4].

Various attachments systems have been used successfully to retain implant overdentures including ball and socket, locator, magnets, telescopic crowns and bars attachments[5].

Implants splinted with bars may lessen the chance of overloading each implant due to the greater surface area, superior biomechanical distribution, and load sharing across implants[6]. There are two types of bar attachments: rigid and resilient categories based on their biomechanical nature. Rigid bar attachments generate a stable occlusal plane, reduces loading on denture-bearing areas, and reduces posterior mandibular ridge resorption . However a key disadvantage of rigid bars is that they may lead to overloading of the supporting abutments or implants, one of the other significant disadvantages of bar attachments include the requirement for adequate interarch distance and the possibility of mucositis due to poor oral hygiene beneath the bar[7].

Recently, new materials based on polyetheretherketone (PEEK) have been introduced to the market. It is an inert material with good biocompatibility. Furthermore, PEEK can reduce stress transmission to the supporting teeth or implants since its modulus of elasticity is nearly equal to that of bone. This polymer compound has several other benefits, including the elimination of allergic reactions and metallic taste, in addition to its excellent polishing powers, low plaque affinity, and exceptional wear resistance[8]. With the advantages of CAD/CAM technologies bar attachments could be digitally constructed from PEEK[9].

Occlusion plays a crucial role in implant prosthodontics as inappropriate management of occlusal variables can lead to implant failure, prosthesis fracture, or eventually bone loss[10]. In order to ensure proper and equalized force distribution, occlusion for implant supported overdentures should include several bilateral, even contacts in centric and eccentric positions[11]. The most widely and commonly used diagnostic instrument for detecting contact simultaneity is the articulating paper. The amount of occlusal load is identified by the size of the marked area on by the articulating paper[12].

In order to eliminate subjectivity in the interpretation of the articulating paper markings, compterized occlusal analysis using devices such as the T-scan was developed. The T-scan III system is an extremely precise method for examining and analyzing the occlusal and articulation relations. [13]

In 2022 a study was conducted to evaluate the effect of computer guided occlusal adjustment versus articulating paper on implant retained mandibular complete over denture on as regard masticatory efficiency and patient's satisfaction and it was found that the group of patients that received dentures adjusted by articulating papers recorded a significant increase in masticatory efficiency and patient satisfaction for 1 week after insertion and there was no significant difference between the two groups for 3& 6 months after insertion.[14].

Another a study compare both methods as

regards the stresses transmitted to the implants in cases with single-implant supported overdentures and it found that higher micro strain values around implants among articulating paper group than T-scan group and that difference was statistically insignificant under bilateral loading and statistically significant under unilateral loading [15].

A third study compare the effect of occlusal adjustment using T scan III and articulating paper on the vertical bone height changes around dental implants supporting mandibular single fixed detachable hybrid prosthesis and it was found that there was increase in vertical bone loss in both group through-out the follow up period and on comparing the two groups there was a significant difference in the vertical bone height changes around the supporting implants after one year from the follow up period where the group of articulating paper showed more vertical bone loss [16].

To the best of the authors' knowledge, studies that compare between these two methods and their effect on bone height changes around implants in bar-retained implant supported overdentures are scarce. Hence, the aim of this study was to compare between using these two methods to direct and perform occlusal adjustment in mandibular bar-retained implant supported overdentures and the effect of this adjustment on alveolar bone loss around the implants.

The null hypothesis was that there will be insignificant differences between the two investigated methods (computerized occlusal analysis and articulating paper).

MATERIALS AND METHODS

16 completely edentulous patients with an age ranging from 55 to 65 (avarage of 60-61years) were chosen from the outpatient clinic of the Prosthodontic Department Faculty of Dentistry Fayoum University. Male patients were chosen to evade the effect of hormonal disturbances on bone specially after menopause. Other inclusion criteria were: good oral hygiene and firm healthy mucosa cover the residual alveolar ridge, skeletal class I maxillomandibular relationship, adequate interarch space to accommodate the bar attachment, adequate bone quality and quantity in the interforaminal area and being free from any systemic diseases.

Patients with parafunctional habits, metabolic bone disorders, or a history of head and neck radiation therapy also patients with TMJ disorders were excluded. Patients were informed of all treatment steps and the need for recalls, and then signed a written consent. The protocol of the study was accepted by the Ethics Committee of the Faculty of Dentistry Fayoum University.

Conventional maxillary and mandibular complete denture with bilateral balanced occlusal concept using cross linked anatomic teeth were constructed for all patients. After complete denture delivery, a tissue-supported stereolithographic surgical guide for implant placement was constructed using the Dual scan protocol to provide precise location and angulation of the dental implants. All raw data were converted into 3D information using blue sky software* for designing of the surgical guide.

Broad spectrum antibiotic** was prescribed 24 hours before the surgery.

A rubber base occlusal index*** was utilized to allow supporting of the surgical guide intraorally, then tissue punching was made to remove soft tissue at the sites which were identified through the surgical guide before using the drills then the fixative pins were used for fixation of the surgical guide Fig 1.

* Blue Sky Plan® V3, Blue Sky Bio, n® LLC, USA.
** Augmentin 1g- Beecham MUP
*** Zeta Plus, putty. C-silicone impression material-zhermack company-Italy

The preparation of osteotomy was done by using the universal surgical kit (NaviGuide) according to the instructions of the manufacturer.

Two implants with diameter 3.7 mm and length 13 mm* were inserted in the canine areas bilaterally according to sequential drilling that was carried out with sterile copious irrigation with saline. The anchorage pins were unscrewed, then the surgical guide was removed from the patient's mouth. Implants were then inserted with a torque of at least 35 Ncm to achieve good initial stability After implant installation, the covering screws were screwed directly into the implants. All patients were instructed to continue the antibiotic for five days after surgery, use oral non-steroidal anti-inflammatory to reduce pain and rinse with Chlorohexidine mouthwash two times per day for plaque control.

After three months all the implants were exposed by making separate small crestal incisions at the implant sites. The cover screws were removed and the healing abutments were placed over the implants to allow soft tissue healing. One week later patients were recalled, the abutments were removed and replaced with two scan_bodies** and the mandibular arch was scanned using calibrated intraoral scanner*** by a skillfully trained operator following a standardized scanning procedure as recommended by the manufacturer. During the scanning process, field dryness was maintained and the patients were instructed not to move(17)

After completing the first scan splinting of the scan bodies was performed by using the plastic part of a bond brush and dura lay acrylic resin****. After that another intraoral scan was made for splinted scan bodies in the same standardized manner described before Fig 2. The splinted scanbodies were removed and a third scan was made to record the soft tissues. The data from both the abutment scan and the soft tissue scan were superimposed on the computer after that, the Standard Tesselation Language (STL) files were downloaded, exported and examined using the Inlab Exocad program***** .

3D reconstruction was used to create the bar's design Fig 3. Using the software, Rhein OT Bar-A****** was chosen as the design and bar as the restoration type. Computer assisted design/computer assisted manufacturing (CAD/CAM) titanium bases******* were selected from the software library. The position of the bar was adjusted according to the titanium bases and the gingiva. It was designed with the following dimensions: 5 mm in height, 4 mm in width, and 1 to 2 mm above the gingival level to facilitate oral hygiene measures. Following the completion of the plan, a PMMA jig was fabricated via 3D printing and checked intraorally for passive fit to confirm the accuracy of the impression.

After passive fit was ensured the STL file was exported to the milling machine******** after the entire design was reviewed to mill the PEEK bars. Next, the bar was examined for any residues or rough spots. Rouge was used to color the titanium bases. After that, the bar was placed over them and taken out to see if there was any interference that needed to be eliminated. It was necessary to confirm that the bar sat easily over the titanium bases.

Sandblasting of the fitting surface of bar copings and titanium bases were carried out using 110 μm aluminum oxide particles******** at pressure of 2-3 bars, then cementation of the bar to the titanium bases was carried out as following , Priming of the

* New Biotech Dental Implant, Guro-gu, Seoul,08381, Republic of Korea.
** Neobiotech Co Ltd, Seoul, Republic of South Korea
*** Medit i600 escaner intraoral 3D.
**** inlay pattern resin - Reliance Dental Mfg.co.
***** Exocad GMBH, Damastadt, Germany
****** OT bar Rhein83, Bologna, Italy.
*******Neobiotech Co Ltd, Seoul, Republic of South Korea
******** Icam v5 times-icore, Hessen, Germany
********BEGO sandblaster, BEGO Bremer GMBH, Germany

Ti-bases and the bar copings was essential. As the bars were PEEK bars a layer of PEEK primer* was used on the bar copings' fitting surface, and it was light-cured for 90 seconds.Metal primer** was applied to the Ti-bases for 30 seconds.

Cementation of the titanium bases took place by dual-cure adhesive resin cement*** one by one individually to cheek the bar seating bar was cemented with Ti base extraorally after check in the oral cavity to confirm that it was properly seated then remove the Ti base out side the patient's mouth and cement it with the bar and remove the excess cement after that screwing it intraorally.

After cementation was complete, the bar was placed into the patient's mouth and tightened to 20NCm using a torque wrench.

A probe was used to visually assess passive fit, and peri-apical radiographs were taken to look for misfits. The one screw test, which comprised screwing the abutment on one side and assessing the fit on the opposite terminal abutment, was then used to confirm it.

A new complete lower denture was constructed in the conventional way. Prior to the pickup process, it was essential to use putty rubber base to block out the undercuts beneath the bar. On the day of delivery, plastic clip attachments**** were secured over the bar. The clip was picked up using autopolymerizing acrylic resin***** intraorally.

All patients were randomly divided into two equal groups according to the method of detection of occlusal errors and adjustment using random number generator and checker.******

Detection of occlusal errors at the day of delivery and after one week was conducted using T scan device******* (computerized occlusal analysis) in Group I and articulating paper******** in Group II. Occlusal adjustment was then carried out in the patient's mouth accordingly.

Group I: The approperiate size of T-Scan sensor was chosen for each patient by using a periodontal probe to measure the width of the maxillary central incisor as recommended by the manufacturer. Patients were seated in an upright position and instructed to bite in centric and clench on the T-Scan sensor Fig (5) three time (and for two seconds each time). This was repeated for both protrusive and lateral movements as well. Based on the 3D and 2D data displayed on the screen, occlusal adjustmenst were carried through intraoral selective grinding Fig(6 a and b). The procedure was repeated untill all heavy contacts (red contact area) disappear and when occlusal simultaneity and nearly equal force distribution between the two arch sides (right and left) was achieved.

Group II: Articulating papers with a thickness of 50 μ and a width of 20 mm were used and replaced once perforated. Marks made by the articulating paper were selectively grinding to adjust high spots in both centric and eccentric positions following the conventional selective grinded rules until even bilateral posterior occlusal contacts were achieved.

Patients were asked to recall for follow-up appointments to ensure that there were no complaints, and to take radiographs to assess changes in implant marginal bone height.

Digital periapical radiography******** was used to measure the changes in marginal bone height surrounding the implants on both the left and right sides. This was done on the day of delivery and implant loading then six months and 12 months later.

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* Visio link, Bredent, Germany
** MKZ-Primer, Bredent, Germany
*** SuperCem, Self Adhesive Resin Cement, South Korea
**** Rhein83 Italy
***** Hard Denture Liner, Promedica GMBH, Germany
****** www. psychicscience.org/random.aspx
******* Tekscan Inc., South Boston, MA USA
******** Articulating paper Products Dentaires SA Vevey, Switzerland
******** Digora, Soredex

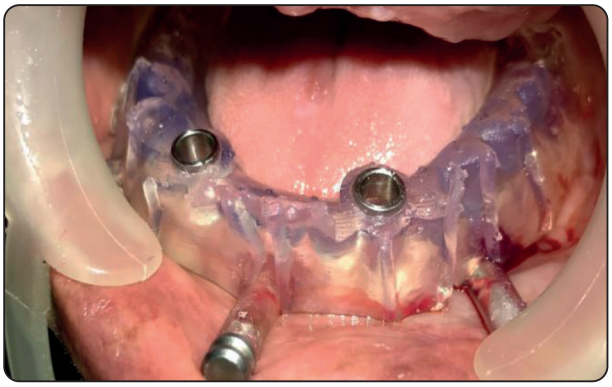

Fig (1) Stereo lithographic surgical guide intraorally.

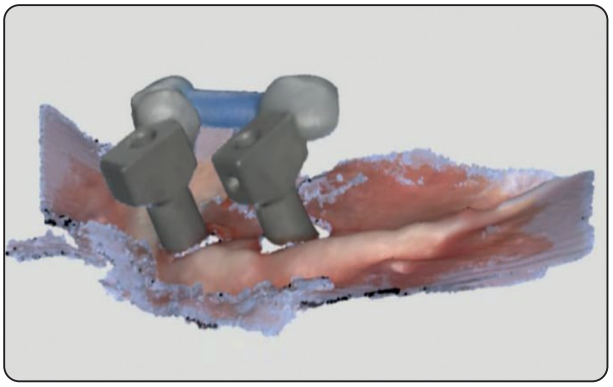

Fig (2) Scanning for splinted two scan bodies.

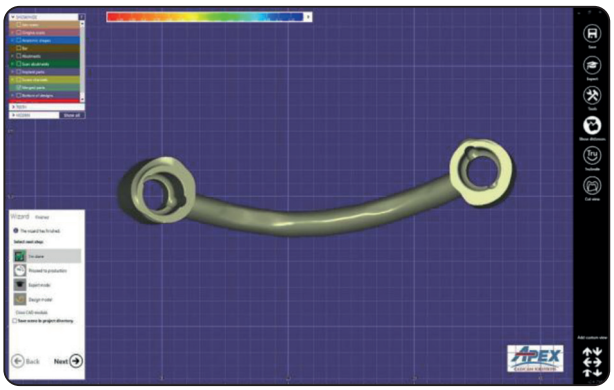

Fig (3) Bar designing software.

Fig (4) PMMA verification jig.

Fig (5) Patient clench during using T scan device.

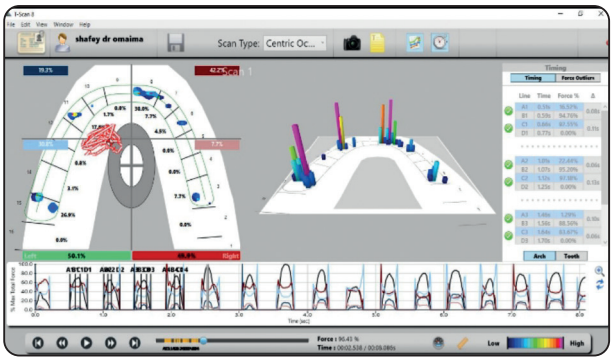

Fig (6 a) T scan III screen displaying data in centric before occlusal adjustment.

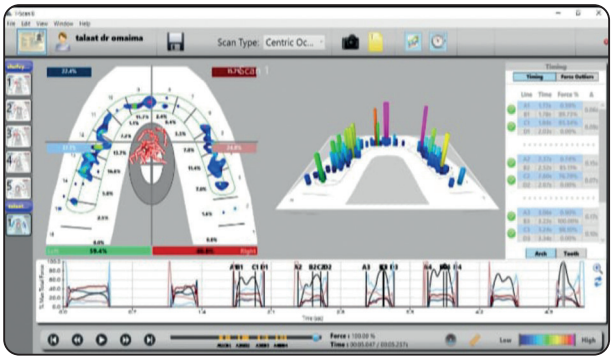

Fig (6 b) T scan III screen displaying in centric after occlusal adjustment.

RESULTS

Statistical analysis

SPSS 16® (Statistical Package for Scientific Studies), Graph Pad Prism, and Windows Excel were used for the statistical analysis, which was then displayed in 2 tables and 2 graphs. The Shapiro-Wilk and Kolmogorov-Smirnov tests were used to examine the provided data for normality, and the results showed that the data came from a normal distribution. Accordingly, comparison between the 2 different groups was performed by the Independent t test. while comparison between different intervals was performed using Repeated Measures ANOVA. The significance level was set at $p \leq 0.05$.

Comparison between articulating paper and T.scan groups

Comparison between both groups regarding amount of bone changes between different intervals in both right and left sides were presented in table (1) and figure (7). Statistical analysis revealed that the amount of bone loss in Group II (Articulating paper) was significantly higher than Group I (T.scan) for all time intervals.

Comparison between different intervals in each group:

Comparison between different intervals in both the right and left sides in both groups were presented in table (2) and figure (8). Tukey's Post Hoc test for multiple comparisons demonstrated that baseline – 12 months showed significantly the highest changes (baseline-6 months was higher than 6-12 months), as presented in table (2) and figure (8).

TABLE (1) Mean bone loss (in mm) in both articulating paper and T.scan groups around right and left implants

		A. Paper		T Scan		Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference		P value
		Mean	Standard Deviation	Mean	Standard Deviation			Lower	Upper	
Right side	**Baseline – 6 months**	0.70	0.12	0.30	0.02	0.40	0.05	0.28	0.52	0.0001*
	6 months – 12 months	0.35	0.04	0.20	0.00	0.15	0.02	0.11	0.19	0.0001*
	Baseline – 12 months	1.05	0.09	0.50	0.02	0.55	0.04	0.47	0.63	0.0001*
Left side	**Baseline – 6 months**	0.38	0.02	0.33	0.01	0.05	0.01	0.03	0.07	0.0001*
	6 months – 12 months	0.31	0.03	0.24	0.06	0.07	0.03	0.01	0.13	0.03*
	Baseline – 12 months	0.68	0.03	0.57	0.06	0.12	0.03	0.06	0.18	0.0001*

Significant difference as P<0.05

TABLE (2) Comparison between different interval within each group:

		Baseline – 6 months		6 months – 12 months		Baseline – 12 months		P value
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	
A. Paper	right	0.70	0.12	0.35	0.04	1.05	0.09	0.0001*
	left	0.38	0.02	0.31	0.03	0.68	0.03	0.0001*
T. Scan	right	0.30	0.02	0.20	0.00	0.50	0.02	0.0001*
	left	0.33	0.00	0.24	0.06	0.57	0.06	0.0001*

significant difference as P<0.05.

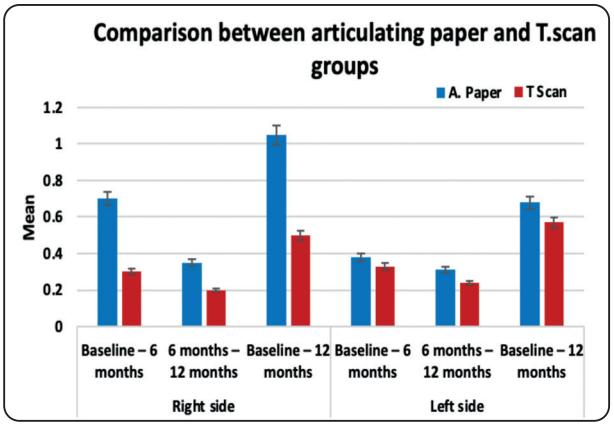

Fig. (7) Bar chart showing mean bone loss (in mm) in both articulating paper and T.scan groups around right and left implants.

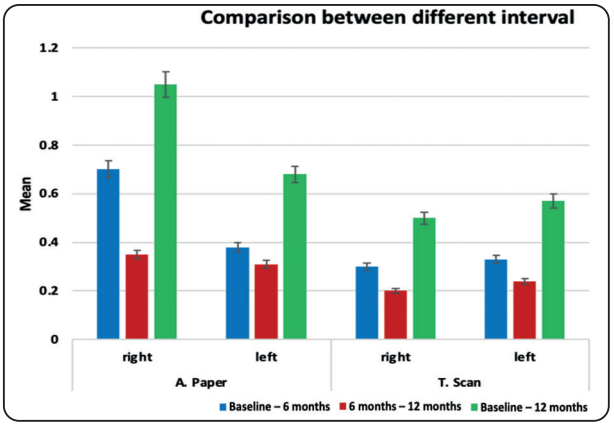

Fig. (8) Bar chart showing comparison between different interval within each group.

DISCUSSION

Based on the results of the current study the null hypothesis could be rejected as there was significantly more vertical bone height loss around the implants when the occlusal adjustment was carried out following the articulating paper method more than the computerized occlusal analysis method.

Guided implant placement using CAD/CAM technology was used in this study to allow the precise planning of implant positions on computed tomography scans and fabrication of accurate surgical guide that permits the surgeon to place implants precisely into the planned positions [19].

Bar attachment was the one of choice in this study. It was stated that Bar-splinted dental implants allow better stress distribution and less prosthetic maintenance in comparison to non-splinted implants [20]

Gianluca Paniz and Jaafar Abdou compared the accuracy of fit of full arch restorations constructed by milling and casting where milled restorations gave much more accurate margins and better passive fit [21,22].

The use of CAD/CAM milled Co-Cr and PEEK bar attachments to support implant mandibular overdenture fulfills the criteria of implant success as indicated by clinical and radiographic outcomes after one year. However, CAD/CAM milled PEEK bar may be advantageous than CAD/CAM milled Co-Cr bar in terms of reduced bone loss [18].

Articulating papers were also been used previously for determination of the location of contact for occlusal contacts but there was a problem with reliability of this procedure and modality in additionthat it can also be deformed due to presence of saliva [23].

Although articulating paper was the most widely used treatment medium for occlusion, T scan can precisely detect the timing of forces and quantify relative forces; nonetheless, force measurements and time measurements are the limitations encountered in everyday practice.T scan overrides such flaws effectively, reliably, and sensitively enough [24].

The main advantage of a T Scan III analysis is that it could detect the amount of force as well as location of the highest intensity contacts of a single tooth which is very specific [25].

The findings of this study are in accordance with the findings of other studies that previously attempted to compare the effect of occlusal adjustment using T scan III and articulating paper that recommend the use of T-scan for occlusal adjustment in complete denture and allows better occlusal stresses distribution as it brings additional information regarding force intensity and occlusal timing resulting in less stresses transmitted around implants [14,15].

Also the findings of our study agree with the findings of the only pervious study that correlated between the method of occlusal adjustment using T scan III and articulating paper and alveolar bone loss and concluded that the use of T scan III device allow for better occlusal adjustment in case of implant supported lower single denture than articulating paper and resulting in less vertical bone loss around the supporting dental implants[16]

Articulating paper markings can be contaminated by the saliva and hence can cause misinterpretation of readings whereas in T Scan III the sensors are synthetic and resistant to salivary wetting of the sensors thus maintaining the accuracy of the recordings [25].

The characteristic articulating paper marking is observed as a central area that is devoid of the colorant and surrounded by a peripheral rim of the dye. The density of these markings does not denote the force of the contact; instead, heavier contact tends to spread the mark peripheral to the actual location of the occlusal contact. Their thickness of 50μ is well above the thickness perception level of the patient and their relatively inflexible base material leads to the formation of a large number of pseudocontact markings[26].

The T-Scan III determines the contact time sequencing and the percentage of relative occlusal force between numerous occlusal contacts and then displays them for all dynamic analysis [27].

This enables the clinician to better identify many interfering contacts that are not readily identified by articulation paper markings. These occlusal corrective adjustments are made by selectively grinding the marks to obtain occlusal stability, multiple contacts throughout the arches that exhibit simultaneity and reduce stress on the occlusal contacts[28].

As a result, there will be less loading placed on the dental implants, which will lessen the amount of bone loss surrounding the implants. It also permits improved force distribution along the supporting implants.

CONCLUSION

Within the limitations of this study, it is possible to conclude that, in the case of an implant supported bar retained mandibular overdenture, the T scan III device allows for better occlusal adjustment than articulating paper, which reduces the marginal bone loss around the supporting dental implants.

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